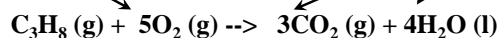


Stoichiometry

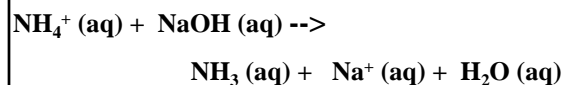
Relationship between the moles of the reactants and the moles of the products in a chemical equation is indicated by Coefficients in the Chemical Equation



Balanced Equations

Mass Balance

Charge Balance



Avogadro's Number

$$6.022137 \times 10^{23} = 1 \text{ Mole}$$

$$1 \text{ g} = 6.02 \times 10^{23} \text{ amu}$$

Amedeo Avogadro (1776-1856) Turin, Italy - Avogadro's hypothesis
1811- equal volumes of gas contain equal numbers of particles

**Atomic Weight
and
Molecular Weight**

**Grams/Mole
(Daltons)**

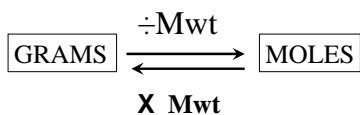
weight is inaccurate these are
actually masses

**Conversion of Mass to Moles
(Moles are the Currency of
Exchange for chemists)**

Example:

20 g of Glucose ($C_6H_{12}O_6$ - Mwt = 180 g/mol)

$$20.0 \text{ g} \div 180 \text{ g/mol} = 0.111 \text{ mol}$$



Moles to Grams (& volume)

Example:

0.500 moles of Ethanol (C_2H_6O - Mwt = 46 g/mol)

$$0.500 \text{ g} \times 46 \text{ g/mol} = 23.0 \text{ g}$$

$$D_{\text{EtOH}} = 0.90 \text{ g/mL}$$

$$23.0 \text{ g} \div 0.900 \text{ g/mL} = 20.7 \text{ mL EtOH}$$

Problem

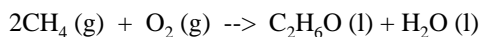
How many atoms of Oxygen are present in 4.9 g of H_2SO_4 ?

$$4.9 \text{ g} \div 98 \text{ g/mol} = 0.05 \text{ mol } \text{H}_2\text{SO}_4$$

$$4 \text{ mol of O atoms per } \text{H}_2\text{SO}_4 \times 0.05 = 0.20 \text{ moles O}$$

$$6.02 \times 10^{23} \text{ atoms/mole} \times 0.20 \text{ moles} = 1.2 \times 10^{23} \text{ atoms}$$

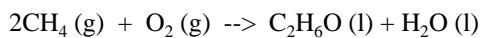
Predicting Chemical Products



$$\begin{array}{r} 8.0 \text{ g} \dots\dots\dots 11.5 \text{ g} \\ \downarrow \div 16 \text{ g/mol} \quad \quad \quad \uparrow \times 46 \text{ g/mol} \\ 0.50 \text{ mol} \quad \times \quad \frac{1 \text{ C}_2\text{H}_6\text{O}}{2 \text{ CH}_4} = 0.25 \text{ mol} \end{array}$$

Moles are the 'currency of exchange' in chemical processes

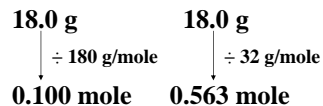
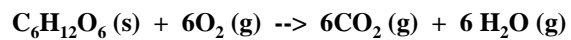
Predicting Amounts of Reagents Needed



$$\begin{array}{r} 8.0 \text{ g} \quad \quad \quad 8.0 \text{ g} \quad \quad \quad \swarrow \times 32 \text{ g/mol} \\ \downarrow \div 16 \text{ g/mol} \\ 0.50 \text{ mol} \quad \times \quad \frac{1 \text{ O}_2}{2 \text{ CH}_4} = 0.25 \text{ mol} \end{array}$$

Moles are the 'currency of exchange' in chemical processes

Limiting Reagents



Which is consumed first? Calculate the moles of O₂ needed for the glucose.

$$0.100 \text{ mole Glucose} \times \frac{6 \text{ O}_2}{1 \text{ Glucose}} = 0.6 \text{ mole O}_2 \text{ needed but only } 0.563 \text{ available}$$

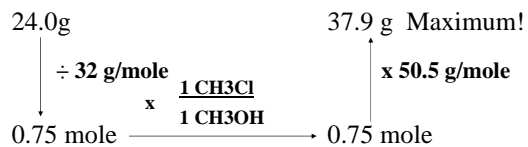
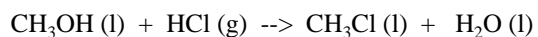
Oxygen is the limiting Reagent!

Yields of Chemical Reactions

In actual chemical processes the amount of product obtained is rarely as large as the amount predicted by theoretical calculations

$$\text{Chemical yield} = \frac{\text{Actual yield}}{\text{Theoretical yield}}$$

Calculation of a Chemical Yield



Only 31.3 g of product are obtained. What is the yield?

$$\frac{31.3 \text{ g}}{37.9 \text{ g}} = 0.826 \xrightarrow{\times 100\%} 82.6\%$$

Concentration

Amount of substance in a given volume (or mass) of solution

grams/liter

moles/liter, Molarity

m/m and m/v % (g/100 g or g/100 ml)

ppt (g/1000 ml)

ppm (g/1,000,000 ml)

ppb (g/1,000,000,000 ml)

Solutions having accurately known concentration

Normal Saline, NaCl 0.85 g/100 ml

Sea Water % composition (mass/mass)

Na 18,980 g/1000 kg (ppm)

Cl 10,561

Mg 1,272

S 884

Ca 400

Dilution of Solutions

Dilution increases the volume without altering the amount of solute

$M \times V = \text{moles}$

initial

final

$M_1 \times V_1 = \text{moles} = M_2 \times V_2$

Calculate the Molarity of con. HCl

Concentrated HCl 35.7% (= 35.7 g/100 g solution)

$$D_{\text{HCl}} = 1.19 \text{ g/ml}$$

In 100 mL there are 119 g solution $\times 0.357 = 42.6 \text{ g HCl}$

$$\frac{42.6 \text{ g HCl}}{35.5 \text{ g/mole}} = 1.20 \text{ moles HCl}$$

$$\frac{1.20 \text{ moles HCl}}{0.100 \text{ L}} = 12.0 \text{ M (moles HCl/L)}$$

What is the concentration of Dilute HCl?

Dilute HCl is prepared by diluting concentrated HCl

$$V_i = 1\text{L}$$

$$V_f = 2\text{L}$$

$$M_i \times V_i = \text{moles HCl} = M_f \times V_f$$

$$\frac{M_i \times V_i}{V_f} = \frac{1 \text{ L} \times 12.0 \text{ M}}{2 \text{ L}} = 6.0 \text{ M}$$

Calculate the Density of Con. H_2SO_4

The concentration of H_2SO_4 is 18.0M and it is also 98.0% (m/v)

Therefore: 18 moles in 1 L of solution

18 mole \times 98 g/mole = 1764 g H_2SO_4 present in 1 liter of Con. H_2SO_4

But 1764 g is only 98% of the mass so

Mass of 1L of solution must be

$$= 1764 \text{ g} / 0.98 = 1800 \text{ g therefore}$$

$$D = 1800\text{g} / 1000 \text{ mL} = 1.8 \text{ g/mL}$$

How many moles of H_2O are in 1 L
of Con. H_2SO_4 ?

1 L contains 1800 g of solution but only 1764
g are H_2SO_4

Therefore $1800\text{g} - 1764\text{g} = 36\text{ g H}_2\text{O}$ in 1 L

$36\text{g H}_2\text{O} \div 18\text{ g/mole} = 2.0\text{ mole H}_2\text{O}$ in 1 L
Con H_2SO_4

Con H_2SO_4 must be 2 M in H_2O !
